METHOD AND APPARATUS FOR BUILDING AND MAINTAINING AN OBJECT-ORIENTED GEOSPATIAL DATABASE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to database construction and maintenance within object-oriented programming paradigms. More specifically, the invention relates to a method and apparatus for building and maintaining an object-oriented database of geospatial data for use with the development and maintenance of topological maps consistent with the Vector Product Format, Raster Product Format, and Text Product Standard developed for use by the U.S. Defense Mapping Agency, now known as the National Imagery and Mapping Agency.

2. Description of the Related Art

The use of maps and geographical characteristics has expanded well beyond the navigator, the cartographer, and the classroom the independent field of topology, which is the study of the characteristics, such as adjacency and contiguity, of geometrical objects that are independent of the underlying coordinate system. The primary purpose for providing topological information in contemporary geographic information systems is to expand spatial analysis capabilities. The National Imagery and Mapping Agency (NIMA) is one of many entities that require timely, relevant, and accurate imagery and geospatial information. NIMA maintains and disseminates databases of geographical data in three main formats: Vector Product Format (VPF), Raster Product Format (RPF), and Text Product Standard (TPS).

While the present invention is directed primarily toward VPF products, a brief introduction to the RPF and TPS formats is presented here because the present invention provides for the first time a system that can incorporate into a single platform geospatial data structured in all three formats.

Raster Product Format (RPF) is defined in MIL-STD-2411, 2411-1, and 2411-2 and was developed to facilitate the interchange of raster data between producers and users of raster data by providing a standard database structure for arrays of pixel values. RPF is a standard data structure for geospatial databases composed of rectangular arrays of pixel values (e.g., digitized maps or images) in compressed or uncompressed form. Data in RPF form is intended to be used by application software on computer-readable interchange media, such as CD-ROM's, directly without further manipulations or transformation. RPF products include those generated from scanned charts, such as those stored in Compressed Arc Digitized Raster Graphics (CADGR), as well as SPOT imagery, such as Controlled Image Base (CIB). In general, RPF data is organized into frame and subframe files. Each frame file contains data for a specific geographical region, defined by a boundary expressed by four (4) latitude/longitude coordinates for a rectangular geographic area. Each frame file also includes a fixed number of data values decomposed into a matrix of subframes, representing color, value, or intensity of the corresponding point. Each product category that represents a single instantiation of RPF, or a family of instantiations of RPF, is described in a separate product specification.

Text Product Standard (TPS) is a textual format using Standard Group Mark-up Language (SGML). TPS provides digital textual information from NIMA hardcopy publications, such as the AMERICAN PRACTICAL NAVIGATOR and SAILING DIRECTIONS. Its information is basically in SGML format. For example, navigators can use TPS data to augment paper or digital charts with valuable information, including accurate directions.

Vector Product Format (VPF) is a standard U.S. Depart of Defense (DOD) format for vector-based digital map products and is defined by U.S. Military Specification MIL-STD-2407, DOD Interface Standard, Vector Product Format, 1996, which is incorporated herein by reference. NIMA, the primary mapping agency for the DOD, developed this standard and is producing an increasing number of digital products in this format. VPF is a standard relational format, structure, and organization for large geographic databases that is based on a georelational vector data model and is intended for direct access by application software. NIMA produces its vector digital map products in this format and offers VPFView as a software application that allows users to browse, display, and perform spatial queries on NIMA data in VPF. NIMA VPF products contain source data from maps, air photographs, satellite data, etc. Other software developers have developed a variety of applications to use and display NIMA-produced VPF data. For example, Environmental Systems Research Institute, Inc. (ESDI) has developed ArcInfo and ArcView to access this data, perform queries, and generally utilize the data within geographic information systems (GIS).

VPF represents a georelational framework based on a vector data model that is well suited to hold data for large geographic databases. Georelational digital vector data are connected points that represent natural and cultural geographic features. Various levels of spatial relationships can be represented in a vector data base such as the VPF data structure. A VPF database comprises three basic types of information for spatial features: spatial geometric properties (locations), non-spatial properties (attributes), and topological properties (relationships). This data is organized into a hierarchical structure of directories, tables, and indices. The root directory for a finite VPF database contains a number of library subdirectories, each representing a specific geographic region and scale. Within each library subdirectory are one or more coverage subdirectories, each representing a related group of feature classes. Each coverage subdirectory contains tables and indices describing its feature classes by attribute (non-spatial) and primitive (spatial) data. Feature data is further subdivided among tile subdirectories within each feature class. Each tile represents a spatial subregion within the library boundaries.

Referring now to FIG. **1**, a typical prior art VPF data structure **100** is shown as a relational database with four hierarchical levels: a database level **10**; a library level **12**; a coverage level **14**; and a feature level **16**. Within these levels, VPF data is maintained in various types of relational database tables, which are stored as files. VPF tables are ASCII or binary files within the directories that are structured as one or more "columns", or fields for different kinds of information, and many "rows" of records for each information type. Such tables are used to feature, attribute, location, geometry, and topology information within the VPF structure. Indices are a special kind of table which have pointers to other tables and records.

At the top level of the VPF structure **100** is the database level **10**, a logical collection of data managed as a unit. Each database will contain one or more libraries **11**, which are generally organized along a geographic categorization, such as political units or latitude/longitude rectangles. An example of a library is the North American continent. Within each library, the data is organized into coverages **13**, which